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Changes in Product Recovery Between Live and Dead Lodgepole Pine: A Compendium

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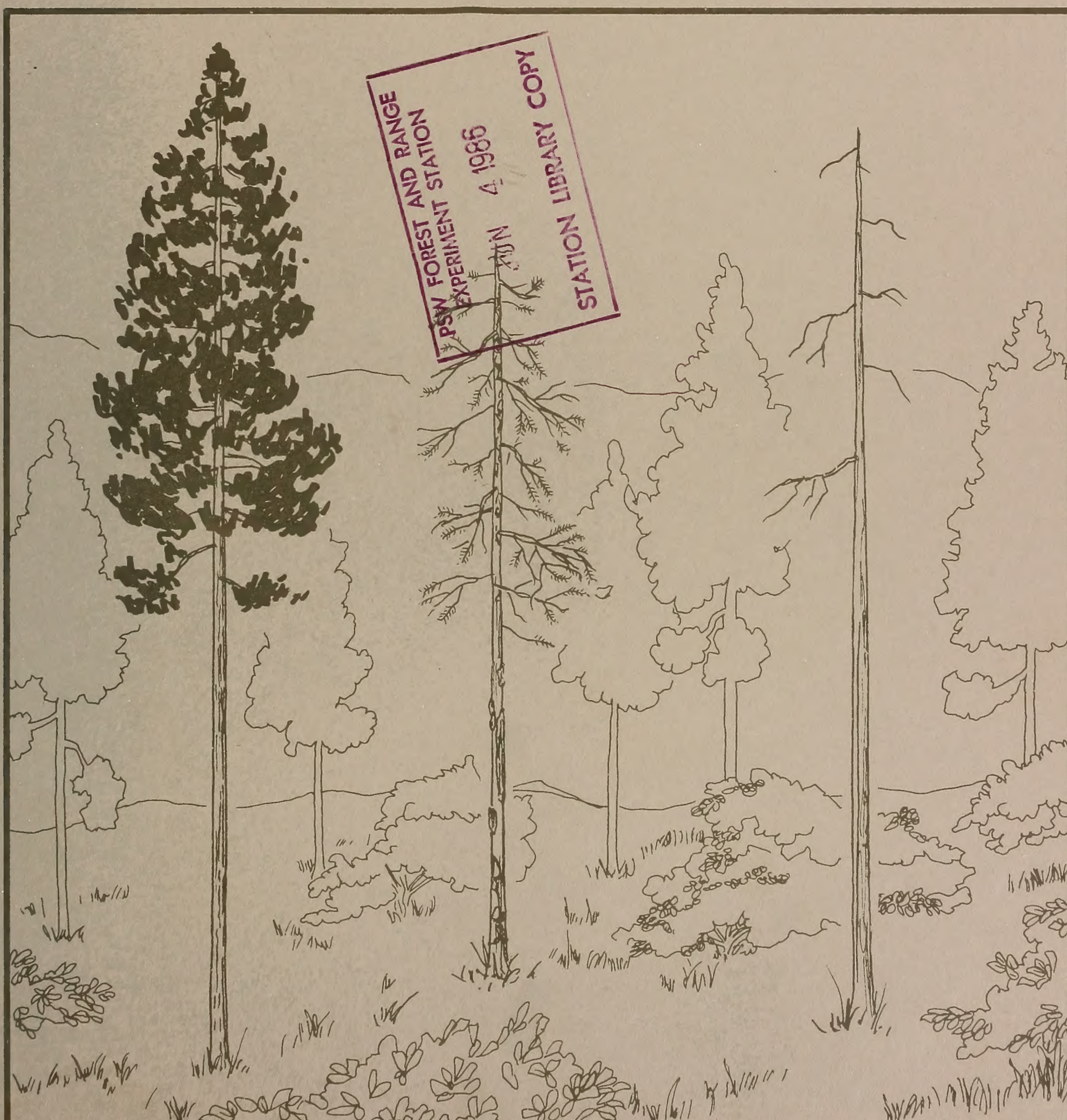

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Abstract

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Six studies were used to compare differences in recovery of volume and value among live, recent dead, and older dead lodgepole pine (*Pinus contorta* Dougl. ex Loud.) in the Western United States. The products studied included boards, random-length dimension, studs, and veneer. For the average size log (12 cubic feet) absolute values were highest for boards, followed by dimension, veneer, and studs for both live and dead timber. The percentage change in value from live to dead, however, showed the reverse order; studs lost the least value and boards the most.

Keywords: Lumber recovery, veneer recovery, dead timber, lodgepole pine, *Pinus contorta.*

Summary

Six studies were used to compare differences in recovery of volume and value among live, recent dead, and older dead lodgepole pine (*Pinus contorta* Dougl. ex Loud.) in the Western United States. The products studied included boards, random-length dimension, studs, and veneer. Although results are presented for the studies individually, the intent was to provide an interpretation of recovery that would be applicable across a wide range of conditions. Results suggest that blue stain occurs before insect-killed lodgepole pine trees can be harvested and that checking also is likely to begin before they can be harvested. The length of time that dead trees remain standing varies by climatic conditions; in colder, drier climates it is usually at least 10 years. Once a tree contacts the ground, deterioration occurs rapidly and within a few years the material is unmerchantable for solid wood products. The wood from dead trees is drier, lighter, and more brash than wood from live timber; and more breakage may occur in harvesting.

In a board mill, both stain and checks are important causes of reduction in volume and value. For structural lumber and core veneer, checks are the main cause for loss in volume and grade, but stain is not important. A higher proportion of low quality products is produced from dead timber; selling this material may be a problem under certain market conditions. Although stain is not an important grading factor, it can be a problem when structural grades of lumber are marketed.

At all mills, the value of products manufactured from dead trees was less than for live trees. Some of the loss in volume of lumber or veneer can be recovered when the value of chips is included in the total log value; losses because of poor grade cannot be recovered. Availability of markets for chips and the value of chips will be critical factors in determining whether small and low quality product items are salvaged. For the average size log (12 cubic feet) absolute values were highest for boards, followed by dimension, veneer, and studs for both live and dead timber. The percentage change in value from live to dead, however, showed the reverse order; studs lost the least value and boards the most. These relationships can vary by log size and do not consider costs.

Contents

Introduction

Lodgepole pine (*Pinus contorta* Dougl. ex Loud.) has the widest range of any commercial tree species in western North America. It is commonly used for light framing lumber and is generally mixed with other species and sold as spruce-pine-fir (SPF).[1] A substantial volume of lodgepole pine is also peeled on 4-foot lathes for use as core stock in plywood plants.

The volume of merchantable dead timber in the northern intermountain area was estimated to exceed 6 billion cubic feet (Van Sickle and Benson 1978). Much of this volume is in lodgepole pine, resulting from normal attrition in stagnated stands and more recently caused by the mountain pine beetle (*Dendroctonus ponderosae* Hopkins) epidemic. In 1981, an estimated 100 million cubic feet of lodgepole pine was killed by the mountain pine beetle in the Western United States (USDA Forest Service 1982). This rate of mortality has been almost constant throughout the West for the past decade.

Because the volume of dead material available is considerable, there are some obvious questions: How much of it can be used? for how long? and for what products? Several studies pertaining to utilization have been reported in detail. Dobie and Wright (1978) reported on lumber value recovery from lodgepole pine in Canada. Plank (1979, 1984) published lumber recovery information from two mills in Wyoming. Snellgrove and Ernst (1983) reported on veneer recovery from dead lodgepole pine in southern Oregon. Tegethoff and others (1977) reported on the use of lodgepole pine for power poles, and Lowery and Host (1979) discussed the use of this material for fenceposts. The use of standing dead lodgepole pine as a raw material for various types of composition board was discussed by Maloney and others (1978). Peckinpaugh (1978) discussed the use of dead lodgepole pine for house logs. Fahey (1980a) rated alternative products based on the value of ovendry tons of fiber.

Objectives

This paper reports results from five lumber recovery studies and a veneer recovery study conducted in the Western United States. The objective is to compare differences in volume and value of typical products recovered from live, recent dead, and older dead lodgepole pine. The intent is to provide an interpretation of six individual studies that would be applicable across a wide range of conditions. Formal statistical comparisons were not possible, however, because all products were not replicated at all locations.

Background

Type and Location of Mortality

The primary cause of mortality in mature and overmature lodgepole pine stands is the mountain pine beetle (Cole and Amman 1980). There are currently two major types of outbreaks in the West. The epidemics in eastern Oregon and in Montana are declining because of depletion of the host species (USDA Forest Service 1982). An epidemic appears to be developing in eastern Washington. Throughout Wyoming, Utah, Idaho, and Colorado, the beetle populations are generally endemic, with localized epidemics.

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[1] Spruce-pine-fir is Engelmann spruce (*Picea engelmannii* Parry ex Engelm.), subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.), and lodgepole pine (*Pinus contorta* Dougl. ex Loud.).

Mountain Pine Beetle Life Cycle

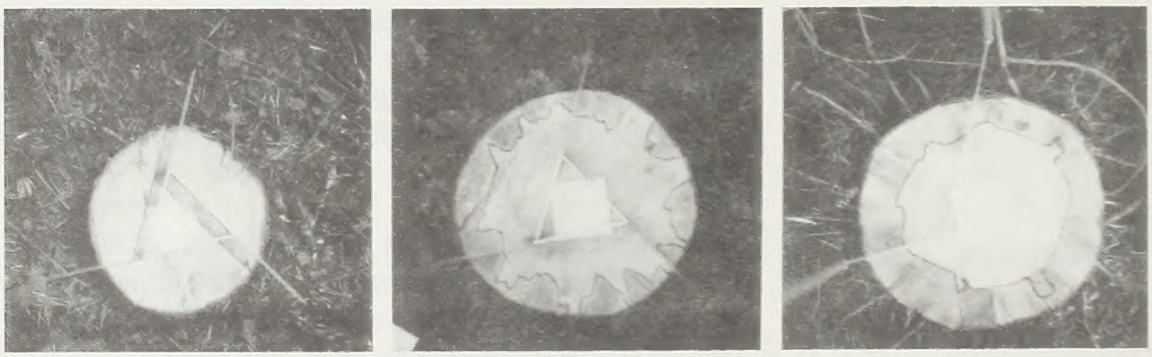
The mountain pine beetle typically has a 1-year life cycle (Furniss and Carolin 1977). Mature insects fly in mid-July or August; during endemic infestations they attack weaker, less vigorous trees, normally 8 inches and larger in d.b.h. and over 100 years old. In epidemics they are less selective. Initial attack is by females; they mine galleries and lay eggs that hatch in about 2 weeks into larvae that overwinter in that stage. Pupation occurs in early July, and with the emergence of adults the cycle begins again. In California two or three cycles may occur in 1 year, whereas in colder climates and at high elevations one cycle may take 2 years.

Infested trees are recognized first by pitch tubes on their trunks and red boring dust in bark crevices and on the ground at the roots. This is followed by discoloration of the foliage from normal green to light greenish yellow, then to reddish brown.

Deterioration

Deterioration occurs in a sequence of events that overlap. First the tree becomes stained, then checked, and eventually it rots at the ground line and falls.

Lodgepole pine attacked by the mountain pine beetle begins to deteriorate because of stain before it is dead. The blue stain fungus, mostly *Ceratocystis* spp., is introduced from pouchlike structures on the head of the beetle. Between 30 and 65 percent of the total main stem volume is stained within 9 months (Harvey 1979). By the time the needles have faded to the point that death is certain, the stain has generally infested the tree to the maximum extent (fig. 1).



1 month 3 months

Figure 1.—Stain spores are carried by the mountain pine beetle; 50 percent of the sapwood is stained within 1 month of beetle attack and the entire sapwood is stained within 3 months.

Physical deterioration is initially caused by drying stresses that appear as splits in the bole of the tree (fig. 2). These splits extend from the bark to the pith and one check (occasionally two or three checks) will develop to relieve the drying stresses. Checks ordinarily take about 1 year to develop from the time of attack, but in cool areas they may take three full summers.

The tree may then stand for an extended period with little or no further deterioration, other than sloughing of bark and surface oxidation, until it breaks off at or near the ground line. Activities of wood-destroying fungi, which ultimately consume the tree, are dependent on both moisture and temperature (Larsen and others 1980). As the trees dry, moisture content in most of the bole drops to approximately 20 percent (Lowery 1978) which inhibits or prevents growth of fungi. A small portion of the tree at the base, however, will maintain the moisture and temperature necessary for fungal growth for short periods in the spring and fall, depending on climate and exposure. In all cases, the trees decay at or near the ground line until

Figure 2.—Checks develop rapidly as a result of drying stresses in trees killed by the mountain pine beetle. The beetle is not a defoliator; therefore, transpiration through the needles causes rapid drying of the stem.

Figure 3.—Rot generally develops only at the base of the tree; the bole above ground level is too dry to support decay-causing organisms. In most areas of the West, trees will remain standing for much longer than 10 years.

they eventually fall (fig. 3). Once the tree contacts the ground, conditions for decay are favorable and deterioration of the main stem is rapid. Few areas in the intermountain west are favorable for activities of decay fungi, but conditions can vary tremendously by geographic area. Trees will remain standing with very little deterioration from 7 to 8 years in eastern Oregon to more than 20 years in the driest and coldest areas in Montana and Wyoming.

Effect of Deterioration on Products

The two primary factors causing losses of grade and volume from dead trees are stain, and checks that become splits in lumber or veneer. Stain affects only products graded for appearance, and grading rules for lumber (Western Wood Products Association (WWPA), 1977, section 744) have these categories: "*Heavy stained sapwood* has so pronounced a difference in color that the grain may be obscured, but the lumber containing it is acceptable for paint finishes; *medium stained sapwood* affects the usefulness for natural finishes, but not for paint finishes; *light stained sapwood* does not materially affect natural finishes." Heavy stain eliminates lumber from 2 Common and Better grades, but has no effect on lower grades of Common lumber. It also has no effect on lumber grade at dimension or stud mills or on core grades of veneer.

Drying checks in trees are graded as splits in lumber and veneer (fig. 4, A and B). Splits are defined as "a separation of the wood due to tearing apart of the wood cells." Splits in lumber are categorized in relation to the size of the piece. The maximum split allowed for a particular grade is shown in table 1. Splits generally limit the grade of boards to 3 or 4 Common; of dimension to Utility or No. 3; and of Studs to Economy Stud. Splits in C grade veneer are limited to one-half inch for one-half the panel or three-eighths inch for the full panel. D grade veneer is generally not affected by splits.

A B

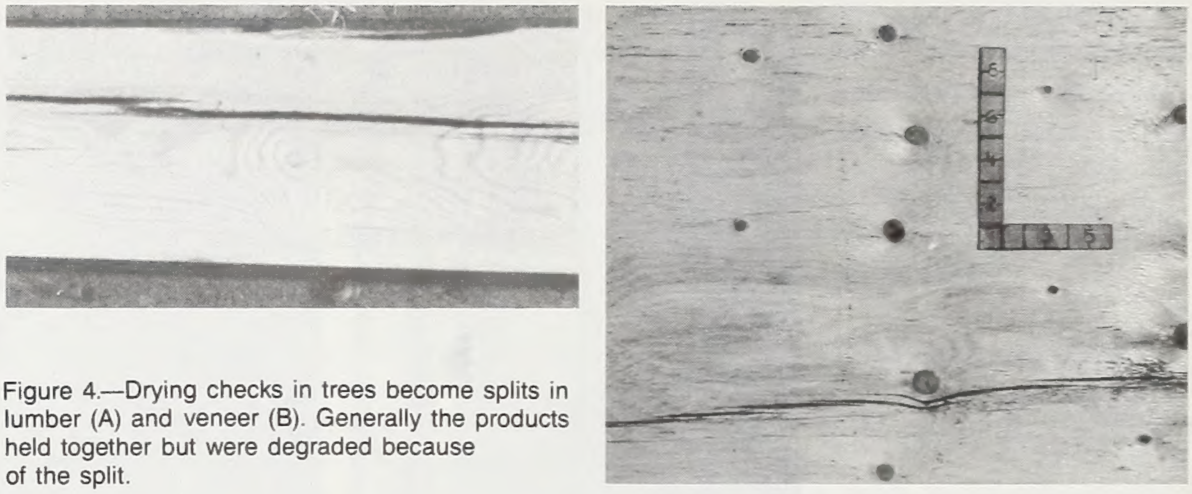


Figure 4.—Drying checks in trees become splits in lumber (A) and veneer (B). Generally the products held together but were degraded because of the split.

Table 1—Lumber grades and limitations for splits[1/]

Grade	Section in WWPA rules	Maximum length of split
Board:		
2 Common	30.12	equal to width
3 Common	30.13	equal to 1/6 length of board
4 Common	30.14	equal to 1/3 length of board
5 Common	30.15	not limited
Dimension:		
Light Framing (2 x 2 to 2 x 4)--		
Standard	40.12	equal to 1-1/2 times width
Utility	40.13	equal to 1/6 length
Economy	40.14	not limited
Stud	41.13	equal to 2 times width
Economy Stud	41.14	equal to 1/4 length
Structural Joists and Planks (2 x 5 and wider)--		
No. 1	62.11	equal to width
No. 2	62.12	equal to 1-1/2 times width
No. 3	62.13	equal to 1/6 length
Economy	62.14	not limited

1/ Grades and limitations are according to Western Wood Products Association (1977).

Figure 5.—Approximate location of individual study areas and types of products at each location.

Methods

Product recovery studies were conducted in six mills at five locations in the intermountain area (fig. 5). The same general techniques were used in all studies. Individual trees were selected, identified, and harvested. Logs were identified by tree and by position in the tree. At the mill, logs were scaled and during the processing each piece of lumber or veneer was identified by the log it came from. Product and log values were based on prices for surfaced dry lumber or dry trimmed veneer.

Sample Selection and Logging

Trees were selected from each study area to sample the variation in diameter and time since death. The distribution of sample logs or trees by type of mill, area, and tree condition is shown in table 2. Tree diameters from the two Oregon studies (stud and veneer mills) were slightly smaller than those sampled in Montana and Wyoming. In the Montana studies, logs from trees were allocated to two types of mills; therefore, diameter of logs rather than of trees is used in table 2. Recent dead trees (1-2 years) had either yellow-green or red needles; older dead (3 years plus) generally had few needles or none. In the Blue Mountains of eastern Oregon, stands killed 1 to 6 years earlier were sampled, and the date of mortality was determined from Ranger District records. In parts of Montana and Wyoming there was little recent mortality in the vicinity of the mill; therefore, getting an adequate sample of recently killed trees was not practical.

The sample trees were sold to the cooperating mills and were logged following normal practices in the area. Logs were tagged to identify the tree and the log position within the tree.

Table 2—Distribution and diameter of lodgepole pine trees by mill type, study location, and tree condition

Mill type and study location	Live			Recent dead 1/			Older dead 2/		
		Diameter			Diameter			Diameter	
	Number	Range	Average	Number	Range	Average	Number	Range	Average
		- - Inches - -			- - Inches - -			- - Inches - -	
				TREES					
Dimension (Wyoming)	120	7-18	10	--	--	--	147	7-18	11
Stud (Wyoming)	108	7-19	11	118	8-21	13	170	8-22	14
Stud (Oregon)	40	6-16	11	80	6-15	10	132	6-15	10
Veneer (Oregon)	63	8-16	12	37	8-17	12	24	8-15	12
				LOGS					
Board (Montana)	173	7-15	10	--	--	--	49	7-12	10
Dimension (Montana)	349	4-10	7	--	--	--	130	5-10	7

1/ Trees dead 1-2 years.

2/ Trees dead 3 years or more.

Scaling

Logs were rolled out in the mill yards and scaled by USDA Forest Service check scalers. In some cases, logs were scaled as "long logs" (generally 32 feet and longer); in other cases logs were scaled as "short logs" (generally 16 feet). Emphasis in analysis is on the percentage of change in recovery; therefore, the difference in scaling lengths between mills is not important. Although Scribner and cubic volumes were measured, only gross cubic volumes were used for analysis and presentation of results.

Cubic volumes are based on diameters that were recorded to the nearest inch and lengths to the nearest foot. The Smalian formula was used to calculate cubic volume of all logs.

Study Mills

The six study mills included two stud mills, two random-length dimension mills, a board mill, and a veneer mill. One stud mill had only one headrig—a four-saw scragg. The other stud mill had two headrigs—a band saw and a four-saw scragg. Of the two random length dimension mills, one had a chipping headrig, the other had a circular saw with a battery edger for sawing cants. The board mill was a conventional band mill with a linebar resaw. The veneer mill produced veneer on a high-speed core lathe, peeling "hot soaked" 4-foot blocks.

Processing

After the logs were scaled, they were processed into the products that each mill normally produced from lodgepole pine. Each piece of lumber or veneer was marked to identify it by the log from which it was produced. All lumber was graded in the surfaced dry condition, and grading was supervised by inspectors from the WWPA, applying grading rules for western lumber (Western Wood Products Association 1977). All veneer was graded in the dry condition under the supervision of grading inspectors from the American Plywood Association (APA), applying grading rules for veneer (American Plywood Association 1974).

Table 3—Indexed prices for lumber grades used to calculate log values[1/]

Lumber grades	2x2 to 2x4	2x6 to 2x12	1x3 and 1x4	1x6 to 1x12
		Dollars per thousand board feet		
Studs:				
Stud	100			
Short Stud	67			
Utility	70			
Economy	47			
Random length dimension:				
Standard and Better	127	130		
Utility	87	80		
Economy	45	45		
Boards:				
2 and Better Common			188	204
3 Common			106	137
4 Common			80	93
5 Common			54	54

1/ Prices based on Western Wood Products Association yearly price summary, 1978.

Product Volumes

Sample measurements were taken to determine the actual thickness and width of all green lumber and veneer. Among the mills, rough green 2 x 4's, for example, range from 1.63 x 3.88 inches to 1.80 x 4.06 inches, whereas the size for surfaced dry 2 x 4's is 1.50 x 3.50 inches. A difference between actual and nominal sizes also occurs for veneer. The nominal half sheet, usually referred to as 27 inches, is clipped about 26 inches wide but is tallied as 24 inches wide. The actual size of the green lumber or veneer was used to account for the total cubic volume, and the nominal size was used to calculate value. Chip volume for logs sawn into lumber was calculated by subtracting the cubic volume of rough green lumber and sawdust from gross log volume. For veneer logs, green untrimmed veneer was subtracted from gross log volume.

Product Prices

To develop values in this report, we needed prices for three products: lumber, veneer, and chips. Only C and D veneer were produced, and both were given the same value—$49 per thousand square feet on a 3/8-inch basis. The price for chips was $40/ovendry ton or $48 cunit (100 cubic feet). Developing useful prices for lumber is more difficult because of the array of items produced and the different prices associated with them.

The values for lumber were developed by indexing prices taken from Western Wood Products Association annual summary for 1978 (table 3). The concept of indexing the prices was based on the assumption that the relationship of prices among grades within a product line changes little over time. For example, the relationship between the price of studs and boards may change somewhat over time, but the price for 2 Common boards relative to 3 Common boards will change little. In this pricing system, Stud grade was chosen as the index item because it was the most common grade sold for lodgepole pine. The price for Stud grade was arbitrarily set at $100/MBF (thousand board feet), and all other grades were set as a

ratio to the price of Stud grade; short studs, for example, were worth 67 percent of the value of Stud or \$67/MBF. Because the Stud grade was set at \$100/MBF, the values developed are useful only for comparisons or as a basis for repricing for current markets. The technique for developing current values from this indexing system is shown under "Application" (see "Repricing," p. 21).

Analysis

The objective of this paper is to compare recovery among live, recent dead, and older dead lodgepole pine and to discuss how type of product, grading rules for products, and mill equipment affected that recovery. Statistical analysis was used only to test for differences among time-since-death classes by type of products. Our experience and knowledge are the basis for the discussion about the effect that grading rules and mill equipment have on recovery.

Four response variables for recovery were used in the analysis:
1. Volume of lumber or veneer (primary product) for each log (cubic feet).
2. Volume of chips for each log (cubic feet).
3. Value of primary product for each log (dollars).
4. Value of primary product plus chips for each log (dollars).

These variables were regressed over the gross cubic volume of each log. From previous research (Fahey and others 1981, Fahey 1983) we assumed that there was a linear relationship between the response variables and log cubic volume:

$$y = b_0 + b_1 x;$$

where:

y = recovery as shown above,
b_0 = intercept,
b_1 = regression coefficient, and
x = log size expressed as gross cubic-foot volume.

Gross cubic feet per log was chosen as our independent variable because it can be used in calculating actual losses in recovery not complicated by the estimate of defect. Cubic feet of rough green lumber was chosen to express volume recovery; recovery in cubic feet for the same product and the same size log varies little among mills, but recovery based on board feet of surfaced lumber varies substantially. No analysis was conducted to confirm this, but our experience indicates that the cubic volume of products varies little based on size of rough lumber. Most of the variation in board-foot recovery is caused by differences in target size and sawing variation among mills. Chip volumes were also expressed as green volumes. Value of primary products was calculated as the total value of all lumber or veneer in the log, and total value includes the value of primary products plus the value of chips.

Regression analysis was used to fit curves to each class, and covariance analysis was then used to compare slopes and intercepts among the live, recent dead, and older dead samples at each mill. Groups that were not significantly different ($P \leq 0.05$) were combined. Where there was a significant difference, the γ_m criterion (Draper and Smith 1981) was used as a further test to determine if differences were practically important. The equations resulting from this analysis are shown in figures 6 to 11; the summary statistics are shown in the appendix.

Results and Discussion

The results are presented by type of product because changes in total value appear to be strongly affected by the product manufactured. Key points about the grading rules for each type of product and the type of mill equipment are discussed at the beginning of each section in "Results," because these factors also affect recovery.

We first discuss changes in volume recovery among classes, followed by changes in grades and average value of primary products in $/MLT (dollars per thousand board feet of lumber tally). Total value, which includes value of primary products (including chips), is discussed last. It is the most important variable, however, because many production decisions, such as edging or trimming, involve sacrificing lumber volume for an increase in lumber grade and volume of chips. The total value includes the interaction of the value of all products.

Boards

These results are based on boards processed at one mill which used a band headrig with a linebar resaw, edger, and trimsaw. No recent dead trees were available for sampling, so information is reported only about live trees and older dead trees, which were heavily stained and deeply checked. The only item produced was 1-inch boards, and most of the volume from live trees was graded 2 Common and Better. The Common board grades (Western Wood Products Association 1977, section 30) are based primarily on appearance of the board. Heavy stain is not permitted in Grades 2 Common and Better, but it is allowed in 3 Common.

There was a major loss in volume of lumber recovered from the older dead trees and a concurrent increase in the amount of chips (fig. 6, A and B). Some of the loss in lumber volume was due to stain, but most of the loss was due to checks. These defects were often removed in the edging process to raise the grade.

In addition to the loss in volume of lumber recovered, there was a loss in the average value of the lumber associated with the change in the grade of the boards. The average grade recovered and average lumber value for the live and older dead samples are shown in table 4. The $/MLT is the average value of the lumber produced; it does not account for the loss in product volume.

Table 4—Average recovery by lumber grade and average value of logs from live and older dead lodgepole pine sawn in the board mill

Tree condition	Lumber grade: 2 and Better Common	3 Common	4 Common	5 Common	Average value of lumber
	Percent				$/MLT
Live	65.0	29.7	5.0	0.3	180
Older dead	13.8	58.7	26.6	.9	164

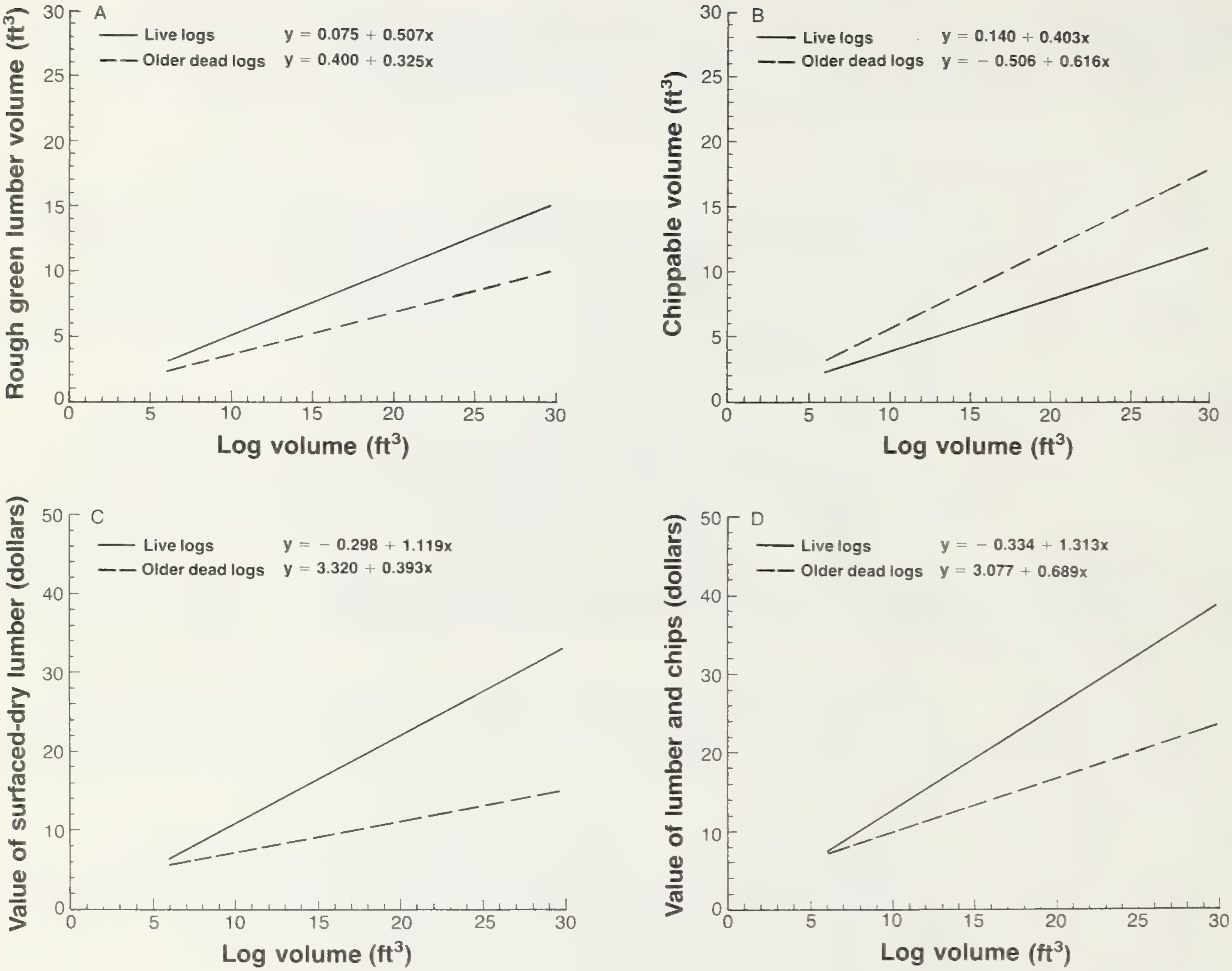


Figure 6.—Estimates of the volume and value of lumber and chips for a mill in Montana producing boards from live and older dead lodgepole pine: A. Relationship of cubic feet of rough green lumber to cubic feet of gross log volume; B. relationship of cubic feet of chippable volume to cubic feet of gross log volume; C. relationship of value of surfaced-dry lumber to cubic feet of gross log volume; D. relationship of value of lumber and chips to cubic feet of gross log volume.

The principal cause of change in \$/MLT between the live and the older dead classes was the decrease in the percentage of 2 Better and Common lumber because of blue stain. A small additional loss occurred because some boards changed from 3 Common to 4 Common. Most of this loss was caused by drying checks, which are considered splits. There was a very small increase in the percentage of 5 Common lumber recovered from the older dead trees, but even in those trees very little 5 Common lumber was produced. A study of western white pine (Snellgrove and Cahill 1980) and second-growth ponderosa pine (Fahey 1980b) showed similar results: Most grade 2 Common and Better was lost within the 1st year; as dead trees deteriorated over time the proportion of lumber in grades 4 and 5 Common increased.

The difference in value of lumber between the live and dead samples (fig. 6C) is due partly to a loss in lumber volume and partly to a reduction in average quality of the lumber recovered. Loss in total value which includes lumber and chips (fig. 6D) was offset very little by the increased value of chippable fiber recovered from the dead timber.

In our opinion, if recent dead timber had been available, losses in volume would have been similar to losses for live trees because only staining would have occurred at this stage. Losses in value for the recent dead trees would, however, have been similar to losses for older dead trees because of the extreme difference in value between 2 Common and 3 Common lumber grades.

Dimension Lumber

Results are based on recovery of dimension lumber from a sawmill with a circular headrig in Wyoming (Plank 1979) and a chipping headrig mill in Montana. Both studies were conducted in areas where no recent dead trees were available, so only live and older dead trees were sampled. The results from each mill are presented separately (figs. 7 and 8); the mills are compared only to illustrate how recovery was affected by different markets for byproducts. The Montana mill was located near a major pulp mill and had a good market for chips; the Wyoming mill had virtually no market for chips but was located adjacent to a pallet plant. These factors affected production decisions at each mill. Both mills produced nominal 2-inch dimension grade lumber, which is graded for structural strength rather than appearance. Stain, therefore, is not a primary cause of degrade, but drying checks are. Most of the lumber was graded under the Light Framing or Structural Joists and Planks rules (Western Wood Products Association 1977, sections 40 and 42), but 1-inch lumber was graded as Commons (section 30).

At the Wyoming mill (circular headrig) there were no differences in the volume of lumber or chips recovered between the live and dead trees (fig. 7, A and B). At the Montana mill the difference between volume recovery of live and dead trees was statistically significant, but it was of no practical importance (fig. 8, A and B). Both mills produced nominal 2-inch dimension lumber. The mill in Montana, which chipped its slabs, recovered only 8 percent of its lumber as 1-inch boards; but the Wyoming mill saved slabs and lower grade lumber from the dead timber for pallet stock and produced 22 percent boards.

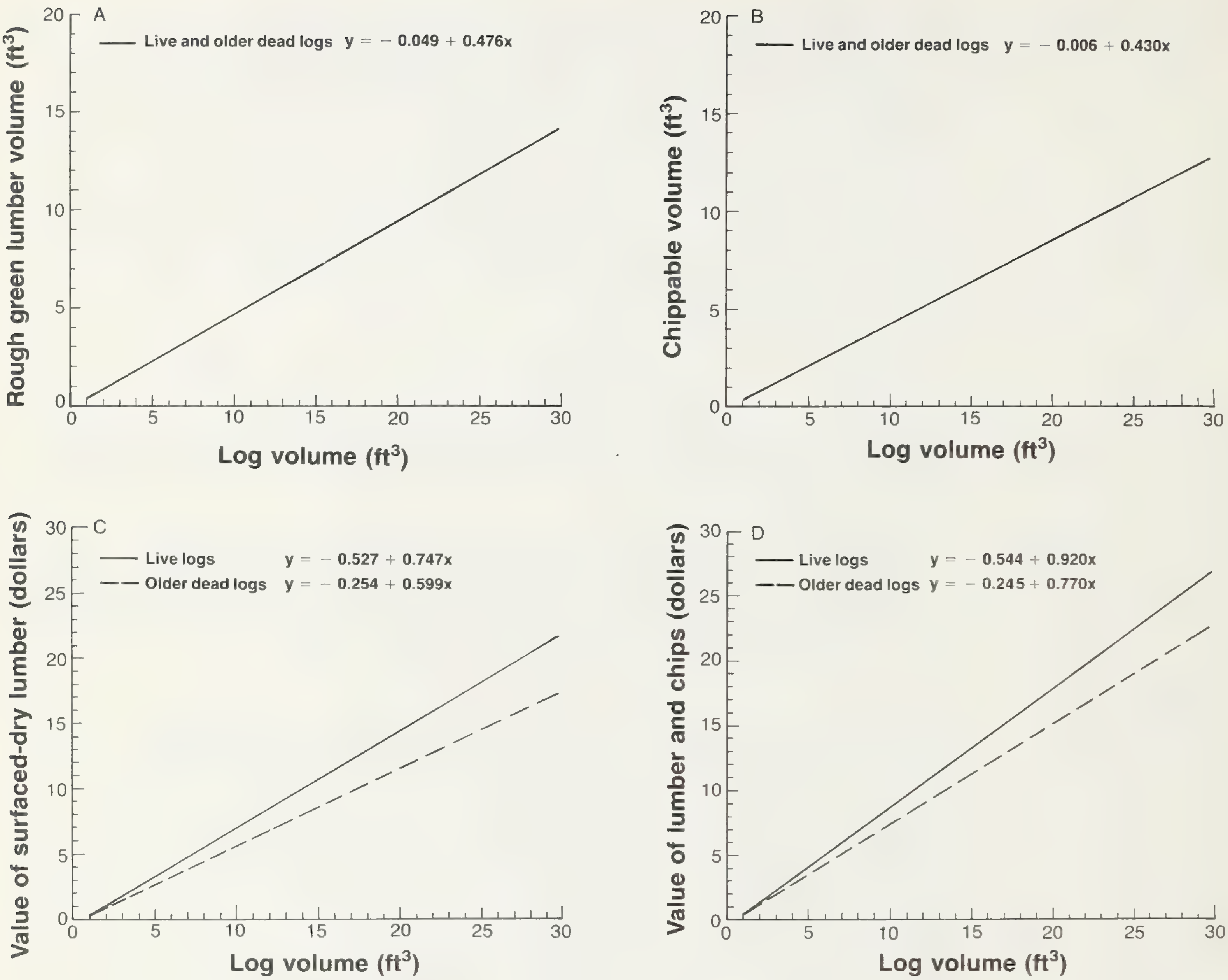


Figure 7.—Estimates of volume and value of lumber and chips for a mill in Wyoming producing random length dimension lumber from live and older dead lodgepole pine: A. Relationship of cubic feet of rough green lumber to cubic feet of gross log volume; B. relationship of cubic feet of chippable volume to cubic feet of gross log volume; C. relationship of value of surfaced-dry lumber to cubic feet of gross log volume; D. relationship of value of lumber and chips to cubic feet of gross log volume.

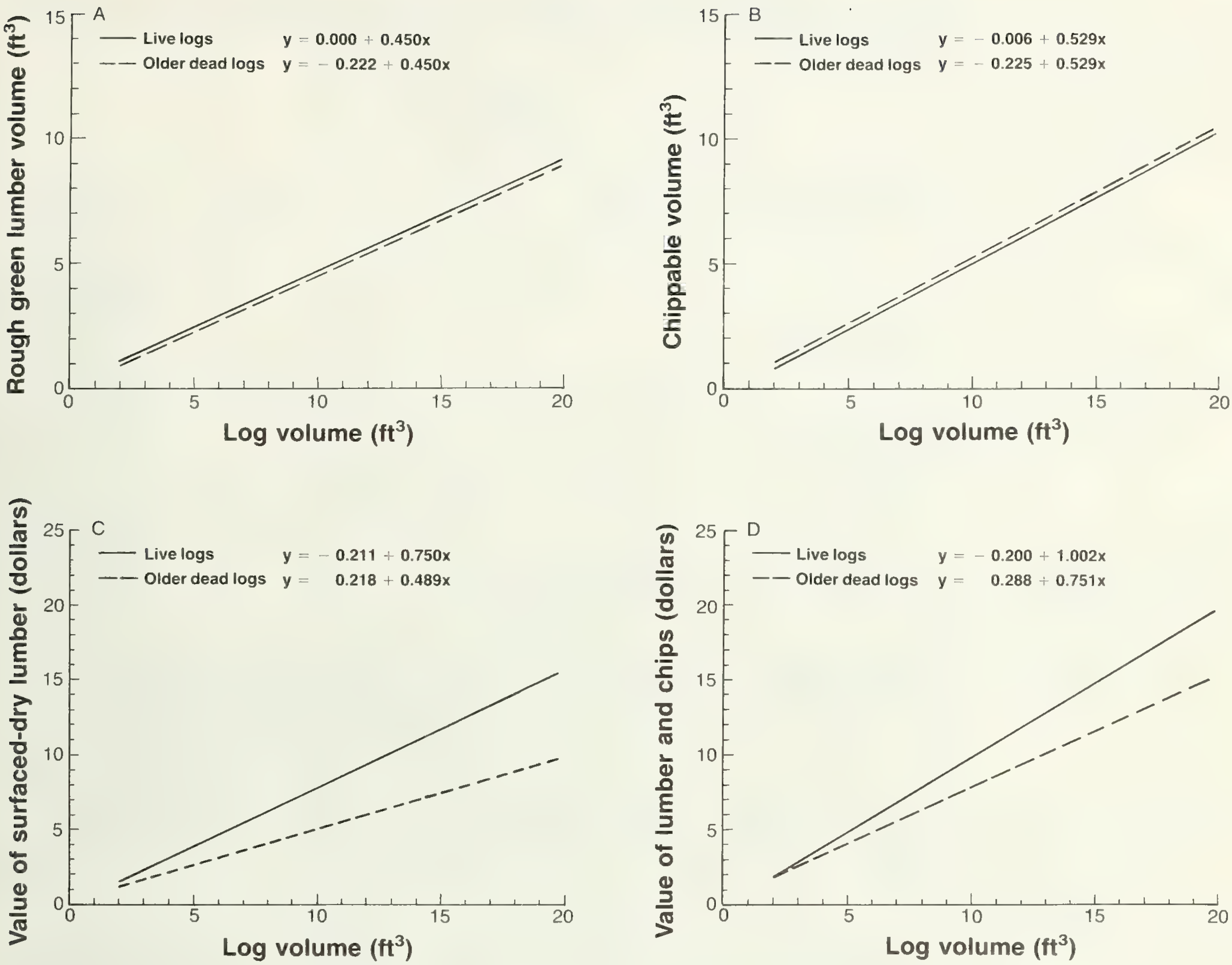


Figure 8.—Estimates of volume and value of lumber and chips for a mill in Montana producing random length dimension lumber from live and older dead lodgepole pine: A. Relationship of cubic feet of rough green lumber to cubic feet of gross log volume; B. relationship of cubic feet of chippable volume to cubic feet of gross log volume; C. relationship of value of surfaced-dry lumber to cubic feet of gross log volume; D. relationship of value of lumber and chips to cubic feet of gross log volume.

Table 5—Average recovery by lumber grade, average value, and lumber recovery factor of logs sawn from live and older dead lodgepole pine trees in dimension mills

Mill type, location, and tree condition	Lumber grade: Standard or No. 2 and Better	Utility or No. 3	Economy	Average value of lumber	Lumber recovery factor
	Percent	Percent	Percent	$/MLT	Board feet per cubic foot
Chipping headrig (Montana): 1/					
Live	81	9	10	122	5.7
Older dead	34	47	19	102	5.7
Circular saw (Wyoming): 2/					
Live	61	22	17	106	6.1
Older dead	37	43	20	91	6.1

1/ Includes 8 percent 1-inch boards.

2/ Includes 22 percent 1-inch boards.

The average lumber grade recovery and the lumber recovery factor (LRF) for the two mills are shown in table 5. The $/MLT from the dead trees was about 15 percent less than from the live trees at both mills—there was a higher proportion of lower grade lumber from the dead timber. The differences in lumber grade recovery and $/MLT between the two mills is mainly a result of the decision at the Wyoming mill to save 1-inch boards for the pallet plant. Because little effort was made to edge or trim lower quality boards, the LRF at the Wyoming mill was higher.

The ability of the circular headrig mill to position the log when it was sawed should, theoretically, have minimized the effect of checks on recovery. Our results show that losses in grade and volume recovery at that mill were in fact less, but the market for chips obscured this relationship. At both mills the change in the value of lumber plus chips (figs. 7D and 8D) was due to the recovery of lower grade lumber, rather than less lumber from the dead timber. Although the Wyoming mill saved smaller and lower quality lumber, the results in total value between the two mills were nearly identical. At the Montana mill, lumber volume was sacrificed to increase grade, but at the Wyoming mill the reverse was true.

Studs

Studs are graded for structural stiffness and are generally used as Light Framing lumber. Some short lumber of Stud grade, however, is used as webbing for prefabricated trusses or is finger jointed and recut for general structural uses. Studs are cut to nominal sizes of 2 x 3, 2 x 4, or 2 x 6 inches and generally are PET (precision end trimmed) to lengths of 96, 92-5/8, and 88-5/8 inches. Stain is not considered a grading defect for studs, and the length of splits is less restrictive for Stud grade than for Standard and Better grades. These results are based on recovery of live, recent dead, and older dead logs in the two stud mills, one in

Wyoming and the other in Oregon. The most common product was the 2 x 4 PET stud that was 92-5/8 inches. As with results from the dimension mills, recovery of lumber was affected by the proximity to markets for chips. The Wyoming mill had two headrigs—a band saw and a four-saw scragg—and most of the lumber was produced by the scragg. All material from the headrigs was passed through a battery edger and was sent to a reclaim area where lumber could be ripped, resawn, or trimmed. Because the Wyoming mill was in an area with a poor market for chips, it salvaged as much lumber as was reasonably possible, including 1 x 3, 1 x 4, and 2 x 2, in addition to studs. The Oregon mill had a four-saw scragg and a combination edger. In contrast to the mill in Wyoming, the Oregon mill had an excellent (in-house) market for chips; therefore, it saved only 2 x 3 and 2 x 4 studs.

For the Oregon study the live and recent dead samples were not significantly different for any of the response variables analyzed, but the combined samples of live and recent dead were significantly different from the older dead (fig. 9). Results of the Wyoming study showed significant differences between the live sample and both of the dead samples for all response variables, but no difference was detected between the two classes of dead (fig. 10).

The proportion of the log recovered as lumber (LRF) for each class of material in the Wyoming study was higher than for equivalent classes in the Oregon study (table 6). Salvaging 1-inch boards and 2 x 2's increased the volume of lumber recovered for all classes.[2] Although the proportion of lumber recovered differed between the two mills, neither mill lost much recovery when the dead logs were processed—about 0.4 cubic foot of lumber for a 12-cubic-foot log (figs. 9A and 10A).

In the Oregon mill there was little change in lumber grades recovered between the live and dead samples; consequently, there was only a small decrease in $/MLT (table 6). That mill made no attempt to increase recovery by salvaging small or poor quality lumber from the dead logs. Conversely, the Wyoming mill obtained higher volume recovery from the dead sample, but lower grade recovery and a corresponding lower $/MLT. By salvaging 1-inch boards and 2 x 2's, the Wyoming mill, when compared with the Oregon mill: (1) recovered more lumber for a given log volume; (2) obtained a higher average value for the lumber recovered from the live sample (3 Common and Better boards are worth more than Studs); and (3) obtained lower average quality ($/MLT) of lumber from the dead sample—small items from the dead trees were of very low grade. Overall, the Wyoming mill recovered a higher total value for both live and dead logs than the Oregon mill (figs. 8D and 9D), but production costs for salvaging smaller items could offset those values. In locations with good markets for chips, the net value of chips probably exceeds the net value of small and low quality lumber.

[2] Some of this increase in LRF was also due to larger diameters in the Wyoming sample.

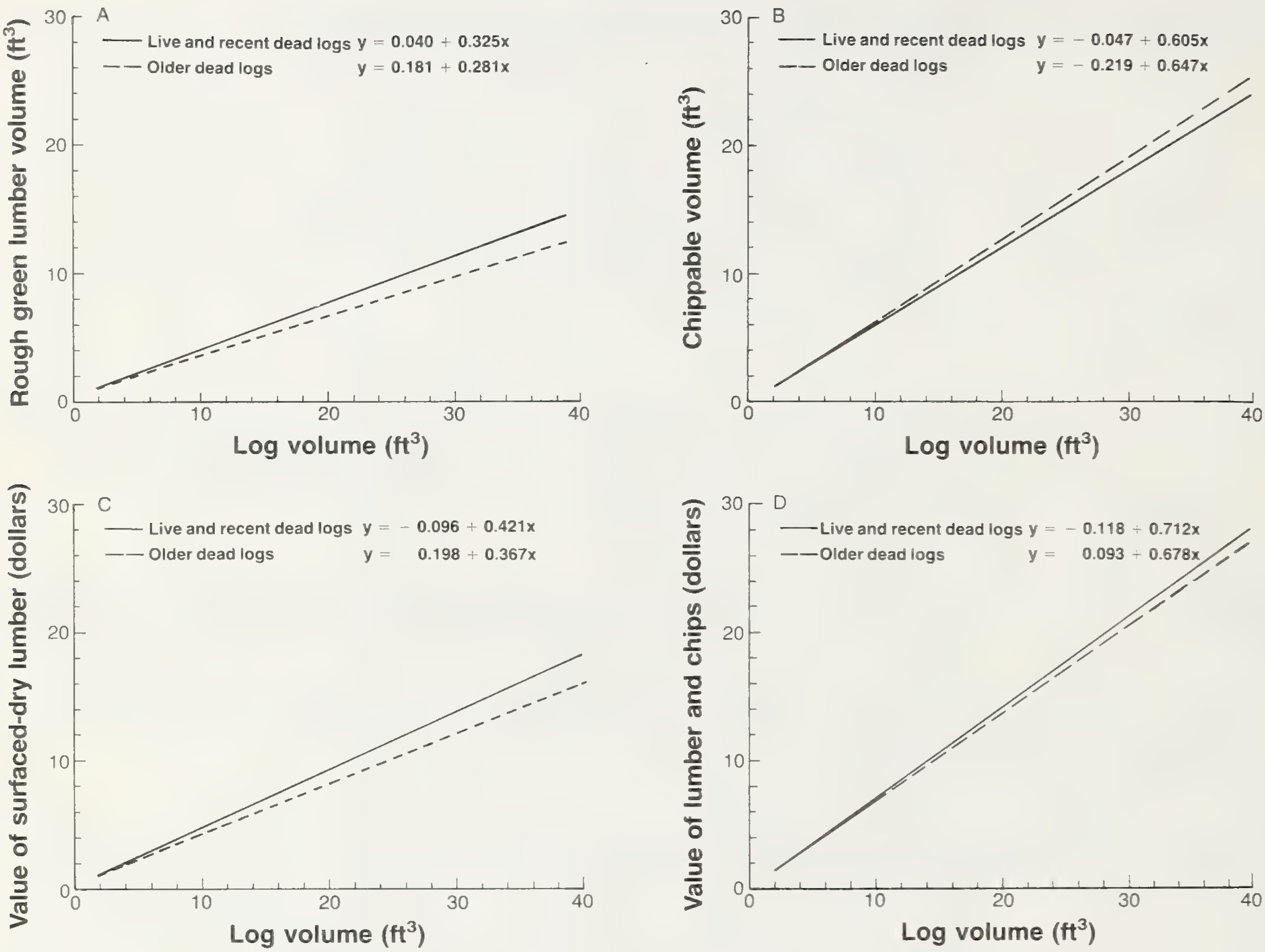


Figure 9.—Estimates of volume and value of lumber and chips for a mill in Oregon producing studs from live, recent dead, and older dead lodgepole pine: A. Relationship of cubic feet of rough green lumber to cubic feet of gross log volume; B. relationship of cubic feet of chippable volume to cubic feet of gross log volume; C. relationship of value of surfaced-dry lumber to cubic feet of gross log volume; D. relationship of value of lumber and chips to cubic feet of gross log volume.

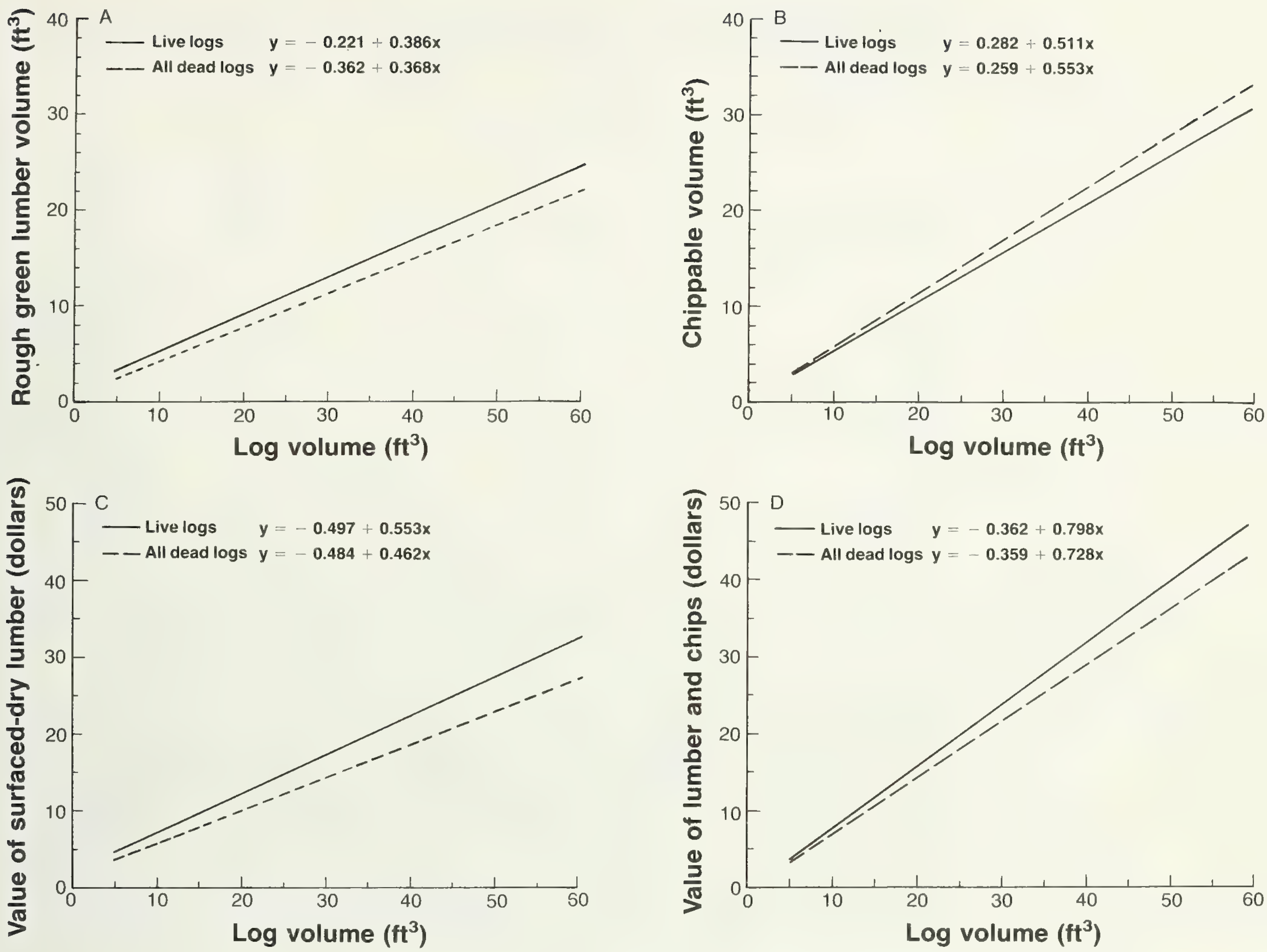


Figure 10.—Estimates of volume and value of lumber and chips for a mill in Wyoming producing studs from live, recent dead, and older dead lodgepole pine: A. Relationship of cubic feet of rough green lumber to cubic feet of gross log volume; B. relationship of cubic feet of chippable volume to cubic feet of gross log volume; C. relationship of value of surfaced-dry lumber to cubic feet of gross log volume; D. relationship of value of lumber and chips to cubic feet of gross log volume.

Table 6—Average recovery by lumber grade, average value, and lumber recovery factor of logs from live, recent dead, and older dead lodgepole pine trees sawn in stud mills

Study location and tree condition	Lumber grades: Stud 1/	Short stud	Economy Stud 2/	Average value of lumber	Lumber recovery factor
	- - - - - Percent	- - - - -		$/MLT	Board feet per cubic foot
Oregon:					
Live	79	4	16	92	4.7
Recent dead	75	10	15	90	4.9
Older dead	75	10	15	90	4.5
Wyoming:					
Live	85	8	7	96	5.4
Recent dead	68	9	23	86	5.2
Older dead	63	12	25	86	5.1

1/ Includes about 7 percent 4 Common and Better at the Wyoming mill.

2/ Includes less than 1 percent 5 Common at the Wyoming mill.

Core Veneer

Core veneer is used in the manufacture of plywood. It is used for the center in three-ply panels, or more commonly, in the crossbands of five-ply panels. It is generally peeled to a specified thickness ranging from 0.160 to 0.205 inch. Typically, veneer is graded C or D for core stock, but the distinction between the grades in this study was not critical because both grades were priced the same. The size of knots or knotholes and splits are the key factors for determining grade; stain is not important. Because limb size is generally small in lodgepole pine, splits were the most important factor in determining grade or volume loss.

Results are based on a study of live, recent dead, and older dead lodgepole pine conducted in southern Oregon (Snellgrove and Ernst 1983). For this study veneer logs were bucked into 8-foot segments, soaked in hot water in preparation for peeling, and rebucked into nominal 4-foot (52-inch) blocks. Blocks were peeled on a high-speed core lathe which was equipped with an automatic charger that chucked the block on geometric center. Veneer was peeled to a thickness of 0.170 inch, and spur knives were set at 50.5 inches. The clipper was set to clip 27 inches automatically with a manual override for clipping out defects. Volume of veneer was calculated on the basis of green untrimmed veneer, from actual length, width, and thickness. Value was calculated from nominal dimensions.

There was a small but statistically significant difference in intercepts but no difference in slopes between the live and recent dead samples for all response variables (fig. 11). Both curves are presented, but the difference between them is of little practical importance. The older dead sample was significantly and practically different in slope from the live and recent dead samples.

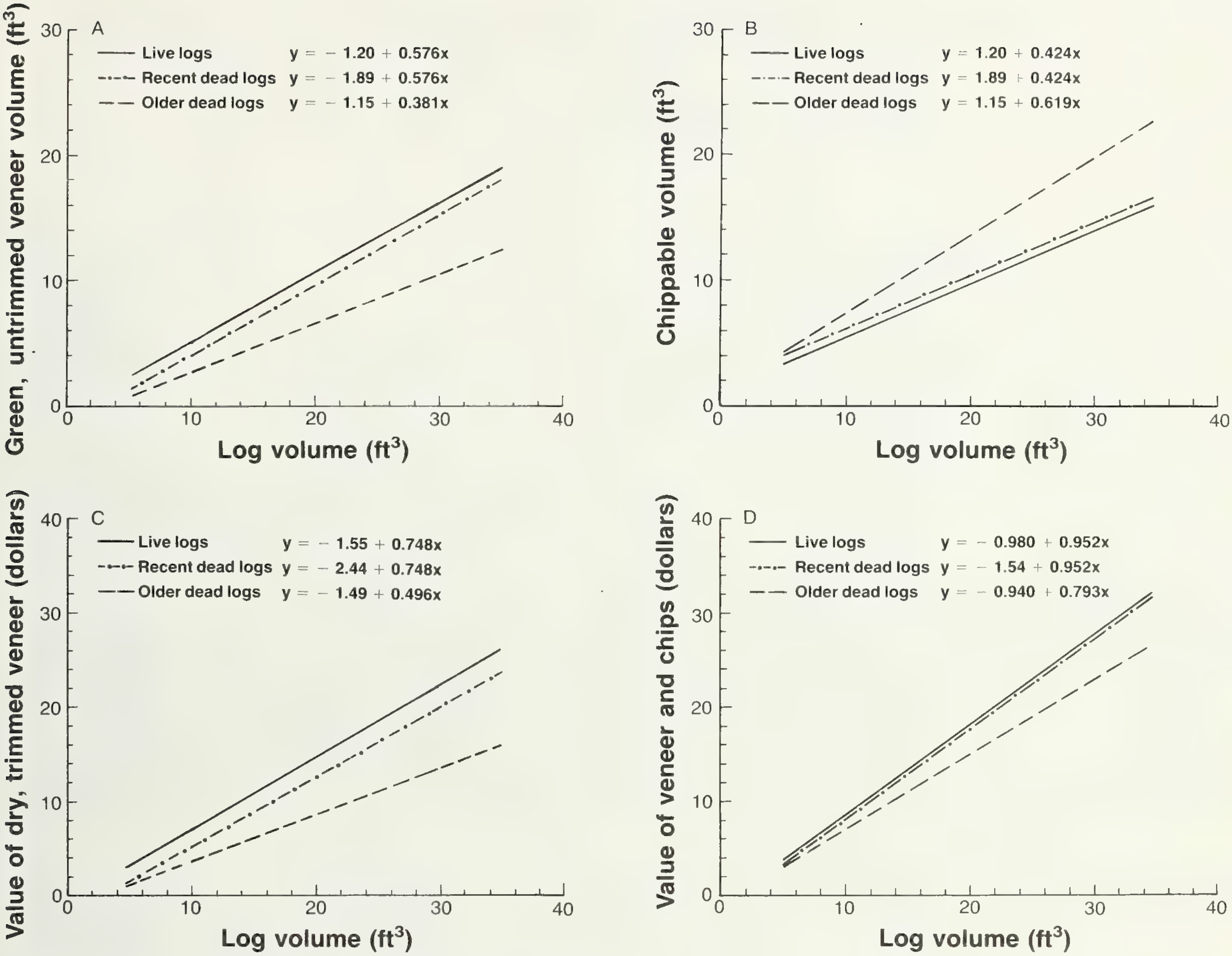


Figure 11.—Estimates of volume and value of veneer and chips for a mill in Oregon producing core veneer from live, recent dead, and older dead lodgepole pine: A. Relationship of cubic feet of green, untrimmed veneer to cubic feet of gross log volume; B. relationship of cubic feet of chippable volume to cubic feet of gross log volume; C. relationship of value of dry, trimmed veneer to cubic feet of gross log volume; D. relationship of value of veneer and chips to cubic feet of gross log volume.

Changes in volume recovered were less than anticipated (fig. 11A). The veneer from the dead logs did not fall apart at checks, and blocks did not break apart during peeling. There was virtually no change in the volume recovered between live and recent dead, but recovery from older dead was substantially lower, averaging about 30 percent less. The volume of chips recovered (fig. 11B) was the reciprocal of the recovery of green veneer—more chips were produced from dead logs.

Grade recovery did not appear to be affected by time since death, but overall averages were 93 percent for grade C and 7 percent for grade D. Because C and D grades of veneer are used interchangeably for core stock and are typically priced the same, grade recovery was not critical in this study. Recovery of half-sheets versus random-width veneer did appear to be related to time since death. The amount of half-sheets decreased from 84 percent for live trees to 79 percent for recent dead and 69 percent for older dead, with corresponding increases in the amount of random-width veneer.

Figure 11C shows the value of veneer recovered for each class, and figure 11D shows the value of veneer plus the value of chips recovered. The differences between classes were less for total value than for veneer value alone because the value of chips recovered offset some of the losses in veneer volume.

Application

The individual estimates of recovery contained in figures 6-11 are useful, but they are based on studies at particular mills which somewhat limits their applicability. We think the relative change in recovery between live and dead timber, then, is the most useful information for extrapolation to other situations. In this section we point out some cautions about using the data indiscriminately, illustrate the use of the equations in figures 6-11, show a method of repricing the data, and conclude by showing how to interpret the information to determine the value of dead timber and how to choose the product to be produced.

Precautions

Gross cubic scale was used as the basis for log volumes in this report; estimates of recovery based on net volumes would be substantially different. Product prices used in this report were based on an index system and were used merely to show relative differences between product lines and time-since-death classes. For determination of actual values, prices must be adjusted as explained on page 21. The product values reported are gross values and do not include any costs.

Estimating Recovery

Recovery can be estimated by using the equations from figures 6-11. The average volume for logs in the studies was about 12 cubic feet. Recovery of a log from a live tree of that size at a board mill (fig. 6) would be as follows:

$$\begin{aligned}\text{Lumber volume} &= (0.07)(\text{number of logs}) + (0.507)(\text{log volume in cubic feet})\\ &= (0.07)(1) + (0.507)(12)\\ &= 6.1 \text{ cubic feet.}\end{aligned}$$

$$\begin{aligned}\text{Chip volume} &= (-0.14)(\text{number of logs}) + (0.403)(\text{log volume in cubic feet})\\ &= (-0.14)(1) + (0.403)(12)\\ &= 4.7 \text{ cubic feet.}\end{aligned}$$

Lumber value	=	(-0.298)(number of logs) + (1.119)(log volume in cubic feet)
	=	$(-0.298)(1) + (1.119)(12)$
	=	$13.13.

Total value	=	(-0.334)(number of logs) + (1.313)(log volume in cubic feet)
	=	$(-0.334)(1) + (1.313)(12)$
	=	$15.42.

In this example, the difference between the volume of the log (12 cubic feet) and the estimated volume of lumber plus chips (6.1 + 4.7 = 10.8 cubic feet) is primarily sawdust. We predicted cubic feet of rough green lumber because our experience indicates that recovery based on rough green volumes varies little among mills for the same product and the same log size, whereas board-foot recovery can vary substantially. The board-foot-per-cubic-foot ratio (Fahey and Snellgrove 1982) can be used to predict board feet of lumber. This ratio would vary by the target sizes of the mill and the type of product. For mills producing 1-inch boards, the expected range would be about 12 to 13 board feet per cubic foot of lumber; for dimension mills, 13 to 14; and for stud mills, 14 to 15.

Repricing

The values for lumber in figures 6 to 10 of this report can be easily adjusted to any market because of the way the prices were originally indexed. The procedure is to calculate the ratio of the current price to the price of an index item from table 3. For a stud mill the index item is Stud grade; for a dimension mill, it is 2 x 4 Standard and Better; and for a board mill, 1 x 4, 3 Common. Information to illustrate repricing is shown in the following tabulation:

Product line and item	Index prices	Current prices
	($/MBF)	
Studs:		
Stud	100	185
Random length dimension:		
2 x 4, Standard and Better	127	197
Boards:		
1 x 4, 3 Common	106	175

To adjust the value for studs to reflect current prices, divide the current price ($185 MBF) by the index price ($100 MBF) and multiply the result by the lumber value calculated from the appropriate equation from figure 9 or 10.

For a 12-cubic-foot log at the Wyoming stud mill (fig. 10C):

$$(\$185/\$100)(\$5.06) = \$9.36.$$

For a 12-cubic-foot log at the board mill:

$$(\$175/\$106)(\$8.04) = \$13.27.$$

To reprice chips, simply compute the volume of chips and apply the appropriate price per cunit.

Table 7—Percent reduction in volume and value for recent dead and older dead lodgepole pine logs compared with a live log for different types of mills[1/]

Item and tree condition	Unit	Board mill	Dimension mill		Stud mill		Veneer mill, Oregon
			Montana	Wyoming	Oregon	Wyoming	
Product volume:							
Live logs	Cubic feet	6.2	5.4	5.7	3.9	4.4	5.7
Recent dead logs	Percent	--	--	--	0	7	12
Older dead logs	Percent	31	4	0	5	7	40
Product value:							
Live logs	Dollars	13.13	8.79	8.44	4.96	6.14	7.43
Recent dead logs	Percent	--	--	--	0	18	12
Older dead logs	Percent	39	31	18	7	18	40
Value of product and chips:							
Live logs	Dollars	15.39	11.82	10.50	8.43	9.21	10.44
Recent dead logs	Percent	--	--	--	0	9	5
Older dead logs	Percent	26	21	14	2	9	18

1/ The comparison is based on a 12-cubic-foot log. Recent dead = dead 2 years or less; older dead = dead 3 years or longer.

Interpretation

The estimated recovery for a 12-cubic-foot live log is presented in table 7 by mill type. The estimates can be used to illustrate relative changes in recovery between live and dead timber. The board mill, for example, lost 31 percent of lumber volume from live to older dead but lost 39 percent of lumber value. Those losses were offset somewhat by the increase in recovery of chips so that the total value of dead timber was about 26 percent less than green timber. The stud mill in Wyoming, which produced and saved small-size items, lost 9 percent of total value but the Oregon stud mill lost only 2 percent. At the veneer mill the loss in total value was about 5 percent between live and recent dead but about 18 percent between live and older dead. Be aware that the percentage change in recovery varies by size of log as well as by type of product; for a 20-cubic-foot log, the board mill lost 23 percent of lumber volume from live to older dead but 49 percent of lumber value, resulting in about a 35-percent loss in total value.

An advantage of using the relative change in recovery is that it should provide reasonable answers regardless of whether the recovery was based on board-foot or cubic-foot volumes. To use these data, a manager would need to know the recovery from live timber. This recovery can then be adjusted, for a given log size, by the percentage change in recovery as calculated from figures 6-11 (illustrated in table 3).

Information in this report can also be used to determine products to be manufactured from live and dead timber. To illustrate, we assume that a band mill has the option of producing either boards or dimension lumber. Recovery based on either volume or value could be used in the decision. When boards are produced from dead timber, the value of the lumber decreases and chip volume increases. For a 12-cubic-foot log at a board mill (table 7) this would result in a 26-percent decrease in total value. When dimension lumber is produced from the same size log, this band mill should lose about the same total value as the dimension mill in Wyoming (14 percent). In our example we used the Wyoming mill because, at that mill, the log could be positioned for sawing. Because it costs more to manufacture boards than dimension, it appears that a band mill would maximize profit by sawing dimension lumber from dead timber but might be able to return a higher profit by sawing boards from live timber.

Metric Equivalents

1 inch = 2.54 centimeters
1 foot = 0.3048 meter
1 cubic foot = 0.02832 cubic meter
1 pound = 453.6 grams
1 ton = 0.907185 metric ton

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Appendix

Statistical Summary

Mill type, location, and response variable	Live logs[1/]		Recent dead logs[1/]		Older dead logs[1/]	
	r^2	$s_{y \cdot x}$	r^2	$s_{y \cdot x}$	r^2	$s_{y \cdot x}$
Board mill (Montana):						
Lumber volume	0.79	0.18	--	--	0.69	0.22
Chip volume	.62	.28	--	--	.85	.20
Lumber value	.72	.12	--	--	.28	.32
Total	.84	.16	–	--	.60	.20
Dimension mill (Montana):						
Lumber volume	.82	.23	–	--	.82	.23
Chip volume	.85	.19	–	--	.85	.19
Lumber value	.77	.28	–	--	.52	.42
Total value	.90	.17	--	--	.74	.26
Dimension mill (Wyoming):						
Lumber volume	.86	.28	--	--	.86	.28
Chip volume	.78	.37	--	--	.78	.37
Lumber value	.80	.38	--	--	.85	.34
Total	.90	.24	–	--	.94	.20
Stud mill (Oregon):						
Lumber volume	.93	.23	0.93	0.23	.80	.35
Chip volume	.97	.15	.97	.15	.86	.30
Lumber value	.90	.29	.91	.29	.77	.39
Total value	.98	.12	.98	.12	.87	.27
Stud mill (Wyoming):						
Lumber volume	.95	.18	.92	.24	.92	.24
Chip volume	.95	.16	.94	.19	.94	.19
Lumber value	.94	.21	.90	.27	.90	.27
Total value	.99	.09	.98	.10	.98	.10
Veneer mill (Oregon):						
Lumber volume	.94	.18	.94	.18	.76	.35
Chip volume	.90	.18	.90	.18	.89	.16
Lumber value	.94	.14	.94	.14	.76	.35
Total value	.98	.09	.98	.09	.95	.12

[1/] r^2 is the coefficient of determination; $s_{y \cdot x}$ is the standard deviation from regression.

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Six studies were used to compare differences in recovery of volume and value among live, recent dead, and older dead lodgepole pine (*Pinus contorta* Dougl. ex Loud.) in the Western United States. The products studied included boards, random-length dimension, studs, and veneer. For the average size log (12 cubic feet) absolute values were highest for boards, followed by dimension, veneer, and studs for both live and dead timber. The percentage change in value from live to dead, however, showed the reverse order; studs lost the least value and boards the most.

Keywords: Lumber recovery, veneer recovery, dead timber, lodgepole pine, *Pinus contorta*.

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